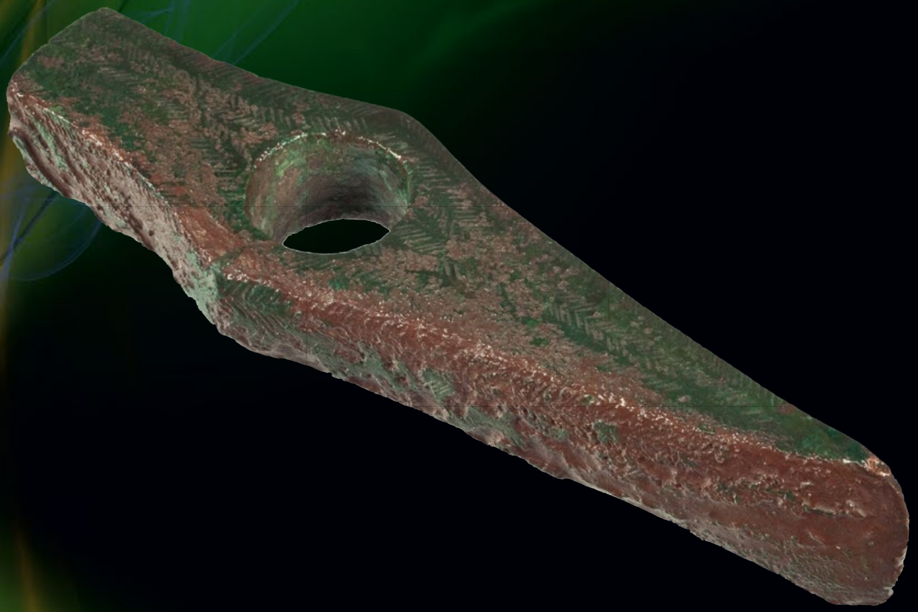
# The Rise of Metallurgy in Eurasia

## Evolution, Organisation and Consumption of Early Metal in the Balkans



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ARCHAEOPRESS ARCHAEOLOGY

ARCHAEOPRESS PUBLISHING LTD
Summertown Pavilion
18-24 Middle Way
Summertown
Oxford OX2 7LG

www.archaeopress.com

ISBN 978-1-80327-042-5
ISBN 978-1-80327-043-2 (e-Pdf)

DOI: 10.32028/9781803270425

Cover: Ljiljana Dinić; Copper hammer-axe, type Pločnik, c. 4600 BC
(from Pločnik, Serbia) - Julka Kuzmanović Cvetković.
Inner back cover: Reconstruction of the world's earliest copper smelting. Green flames come from the extraction of metal from malachite. Experiments at Pločnik, Serbia (2013) - Marko Djurica

Copyeditor: Kate Sharpe

*To the memory of Borislav Jovanović, our colleague, friend and inspiration*

*(1930 – 2015)*

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## Chapter 52

# Balkan metallurgy in a Eurasian context

Miljana Radivojević and Benjamin W. Roberts

As outlined in Chapter 2, three key lines of enquiry shaped *The Rise of Metallurgy in Eurasia* project and underpinned the research questions. Firstly, there are competing views about whether metallurgy in Eurasia had a single origin or arose in multiple places. There are also different perspectives regarding the ways in which pre-existing technical knowledge influenced and inspired the emergence of this new technology. Further discourse relates to the manner in which this early metallurgy was organised across the *chaîne opératoire* of metal production and use and developed across a range of metals and alloys. Each of these three themes are fundamental to early metallurgy across the world (see papers in Roberts and Thornton 2014). These are areas of investigation with a deep history of scholarship and a wide range of competing explanatory models.

That these lines of enquiry can be re-evaluated in the Balkans is due to the integrated theoretical and methodological approach of *The Rise of Metallurgy in Eurasia* project, which has extended the scientific investigation beyond the 'when' and the 'where' of early metallurgy to include explorations of 'how' and 'why'. The project sits firmly within an emerging trend, highlighted by Thornton (2009) as a paradigm shift and evident in global early metallurgical research published in a special double edition of the *Journal of World Prehistory* (Thornton and Roberts 2009 and papers in volume 22) and subsequently in Roberts and Thornton (2014). There is now an identifiable convergence in the scholarship of early metallurgy towards the need to define and analyse the theories and underlying evidence surrounding concepts of invention (see papers in Roberts and Radivojević 2015; Frieman 2021) and innovation (e.g. Burmeister *et al.* 2013; Maran and Stockhammer 2017 Ottaway 2001; Rosenstock *et al.* 2016; Scharl 2016; Frieman 2021). In addition, there is a much stronger expectation that all the available evidence—from ore sources to finished objects—is analysed using a more holistic approach (cf. Ottaway 1994; Shimada 2007), and that results are then compared, contrasted and integrated with comparable analyses of contemporary craft production and consumption in other materials and in broader societal contexts (Miller 2005, 2007).

This dynamic academic environment inspired the six specific research questions that underpinned *The Rise of Metallurgy in Eurasia* project:

1. How did the mineralogical and technological basis for early metal production in the Balkans emerge and evolve during the 6th–5th millennia BC?
2. To what extent was metallurgy related to pottery technology and production, and how did pre-existing technological knowledge influence the emergence of metallurgy?
3. How were ore sources, smelting, and casting connected and organised?
4. Where did the smelted metals circulate?
5. What metal types were being made and how did these evolve?
6. Was there a close relationship between ore sources, metallurgical technology, and artefact types?

This chapter begins by considering the first two themes described above, surrounding the origins of metallurgy, and addressed through research questions 1, 2 and 5. We then turn to the final theme relating to early metallurgy and society with research questions 1, 3, 4 and 6.

### Origins

Scholarship debating the origins of metallurgy in the Balkans dates to the early antiquarian period in the mid-19th to the early 20th century (Childe 1944; Grbić 1929; Von de Pulsky 1884) and consistently equated technological advancement, as expressed through evidence of pyrotechnological abilities, with temporal and societal change (see also reviews by Pearce 2019; Schier 2014a;). This model also acknowledged the unique historical circumstances that may have dictated variations in the dynamics of innovations, and in their adoption and adaptation (Childe 1951). The mid–late 20th century saw the proposal of two highly influential ideas that are still structuring the current debates: the identification of local metal-using communities representing new Balkan Copper Age, Chalcolithic or Eneolithic societies (e.g. Gimbutas 1980; Jovanović 1971; Lichardus 1991c; Renfrew 1969) and the introduction of metallurgy through an external population group, as represented through archaeological cultures migrating into the Balkans from the East (e.g. Childe 1929; Garašanin 1973).

The continued importance of Balkan metallurgical origins in archaeological scholarship is evident

The Rise of Metallurgy in Eurasia (Archaeopress 2021): 601–618

in the use of some of the earliest applications of radiocarbon dating in world archaeology to challenge existing '*Ex Oriente Lux*' interpretations with a model of independent invention (Jovanović and Ottaway 1976; Renfrew 1969, 1970; contra Wertime 1964, 1973). Debates on early metallurgy in the Balkans and Anatolia/Near East rapidly divided scholars into advocates of either independent invention or of migration/diffusion (see Bognár-Kutzián 1976 for a summary). Although highly controversial at the time (Makkay 1976: 263), early radiocarbon dates have now become widely accepted. The independent invention model for Balkan metallurgy was subsequently reinforced by the quantity, typology and metallurgy of cast shaft-hole axes (Charles 1969), the ability to calibrate the new radiocarbon dates using dendrochronology (Renfrew 1973) and the stratigraphical demonstration at the excavations at Sitagroi, Greece, showing that the Central Balkan Vinča culture preceded the Early Bronze Age of Anatolia (i.e., Troy I) by more than two millennia (Renfrew 1979: 139). Further supporting evidence accumulated during the 1970s with the excavation and relative dating of copper mines at Ai Bunar (Chernykh 1978a, 2008a) and the discovery of substantial numbers of the earliest gold—and copper—objects at the cemetery of Varna in Bulgaria (Ivanov 1978b; Ivanov and Avramova 2000). The '*Ex Balcanae Lux*' model (Todorova 1978) represented a new paradigm and caused a widespread re-appraisal of the origins of early technologies in the region (see Sterud *et al.* 1984 for a summary). As Thornton (2001) dryly noted, the major advocates for an independent invention of southeastern European metallurgy were also the most adamant diffusionists for Neolithic subsistence and the origins of the Indo-European languages (Renfrew 1987; Gimbutas 1973).

In addition to dominating the agenda for the 'when' and 'where' for the origins of metallurgy, Renfrew's (1969) suggestion of a direct connection between the production of graphite painted ceramics and the invention of copper metallurgy also provided a new explanatory framework for the 'how'. This pyrotechnological transfer model was subsequently also advocated by Gimbutas (1976a), however, this claim was not investigated from a comparative perspective until nearly four decades later (Amicone 2017; Amicone *et al.* 2020; see Chapter 44). A partial model for the 'why', that went beyond the hindsight of assumed ideas of value and desirability of metals as used by both advocates of independent invention and diffusion, was provided by Glumac (1991). He made the connection between the use of copper minerals for decoration and early metal use in the context of the Balkans – an approach subsequently extended across Anatolia and the Near East by Thornton (2001). The early use, across the Starčevo and subsequently early Vinča culture occupation horizons, of a specific type of copper minerals (black-and-green manganese-rich copper carbonates) that were later smelted to produce the earliest known copper metal, has most recently been shown to be a unique technological trait of Balkan copper and tin-bronze metallurgy, reinforcing the argument for independent invention (Radivojević *et al.* 2010a; Radivojević 2013, 2015).

There are consequently three definable, yet partially inter-related, models for the mineralogical and technological basis underpinning the emergence of metallurgy in the Balkans during the 6th–5th millennia BC (Research Question 1). All are primarily focussed on copper minerals/ores and the ambiguous relationship with ceramic pyrotechnology (Research Question 2). Underlying each of these models are the motivations of the people involved in identifying, selecting and smelting copper ores and their knowledge of and relationship with pre-existing pyrotechnologies. However, it is argued that the singular and uneven focus of early metallurgy scholarship has served to obscure the presence of polymetallism whereby multiple metals were being produced, circulated, used and deposited by the same communities in the same region at the same time (Radivojević *et al.* 2013). The mono-metallic perspective also serves to significantly underplay the deliberate manipulation of metal compositions whether by using complex ores or the addition of other metals, thus creating differences in colour, hardness and castability. It is therefore imperative to adapt these three models when evaluating the evidence for lead, gold, tin bronze and silver in the Balkans (Research Question 3). Each of the models will be evaluated against the pre-existing data as well as the new evidence from *The Rise of Metallurgy in Eurasia* project regarding minerals and ores, Balkan-Anatolian connections and pyrotechnology.

These models are:

1. The migration of individuals and groups from the east with the necessary knowledge relating to the selection of copper minerals/ ores and expertise in pyrotechnology.
2. The transmission, via existing socio-economic networks, of knowledge and expertise relating to copper ores, copper minerals and pyrotechnology from the east into communities in the Balkans.
3. The independent invention of metallurgy by communities in the Balkans who exploited the rich abundance of copper minerals and their knowledge of them and, through time, adapted their pyrotechnological expertise to smelt metal.

## Ores, pyrotechnologies and Balkan-Anatolian connections

Evidence suggests that use of copper mineral and native copper in neighbouring Anatolia and the Near East occurred much earlier than in the Balkans as detailed in Chapter 3. This chapter also highlighted the frequency of copper minerals recorded at early Vinča culture settlements (pre-5000 BC), including the sites of Belovode and Pločnik, as demonstrated in earlier excavations (see Chapters 5 and 6). *The Rise of Metallurgy in Eurasia* project confirmed the presence of copper minerals in the pre-5000 BC phases at each site (see Chapters 11 and 26) and the careful excavation and recording techniques further demonstrated that copper minerals were extensively sourced, identified, selected, carried back to settlements and manipulated in the centuries prior to any evidence for copper smelting (cf. Radivojević 2015).

It is beyond doubt that the practice of using green minerals was transmitted to the Balkans from Anatolia, particularly given its association with early agricultural communities and attested migration and other movements (e.g. Ammerman and Cavalli-Sforza 1971; Brami 2017; Furholt 2017; Ivanova 2020; Mathieson *et al.* 2018; Racimo *et al.* 2020; Rosenstock *et al.* 2016; Shennan 2018; Silva and Vander Linden 2017). However, whilst the first model of migrating individuals and groups from the east is strongly supported with regards to identifying and exploiting copper minerals in the Balkans, the question remains as to whether the ability to undertake copper smelting derived from the same source.

As detailed in Chapter 5, the archaeometallurgical analysis of five small copper slags from Trench 3 at Belovode, together with the radiocarbon dating of the excavated horizon in which they were found, that provided evidence for copper smelting at *c.* 5000 BC (Radivojević *et al.* 2010a). The further evidence of two copper metal droplets found in a sealed refuse pit in Trench 18 at Belovode (Feature 21, see Chapter 11), excavated for *The Rise of Metallurgy in Eurasia* project and dated to the 49th century BC, provides a more contextually and chronologically secure dating for copper smelting but nonetheless confirms the earlier interpretation for *c.* 7000 year-old metallurgy. Beyond the Balkans, the closest evidence to the copper smelting to Belovode comes from Tal-i Iblis in southeastern Iran in the early centuries of the 5th millennium BC; this is only relatively dated to as it comes from the excavation of spoil heaps (Frame 2012). Until very recently, the assumed metallurgical activities at Çatalhöyük had stimulated scholarly debates due to an unusually early date of *c.* 6500 BC for a find that appeared to contain features of a metallurgical 'slag' (Cessford 2005; Mellaart 1964; Neuninger *et al.* 1964). The argument that the Neolithic Çatalhöyük communities were possibly smelting metal has since been discussed in the literature and found both support (Hauptmann 2000; Hauptmann *et al.* 1993; Strahm 1984) and open caution (Birch *et al.* 2013; Craddock 2001; Muhly 1989; Pernicka 1990; Radivojević *et al.* 2010a; Roberts *et al.* 2009; Tylecote 1976). A full re-analysis of the original metallurgical 'slag' from Çatalhöyük and revised contextualisation showed that this sample was a burnt copper mineral, probably deposited as a green pigment in a burial and subsequently baked during a destructive fire event in the dwelling in which it was discovered (Radivojević *et al.* 2017).

Further fieldwork evidence for copper smelting in Anatolia dates from late 5th / early 4th millennium BC occupation of the eastern Anatolian site of Değirmentepe (Lehner and Yener 2014; Mehofer 2014), although no analytical evidence of this find is known to the authors. In the southern Levant, the more secure evidence for copper smelting dates to the later 5th millennium BC (Golden 2010, 2014; Klimscha 2013). To the west, the earliest evidence for copper smelting in Central Europe and the Central Mediterranean also dates to the late 5th millennium BC (Dolfini 2013, 2014; Höppner *et al.* 2005; Scharl 2016; Turck 2010). The potential early 5th millennium BC date in the Western Mediterranean at Cerro Virtud, southeast Spain remains disputed and over a millennium earlier than any other copper smelting site in the region (Gauss 2013; Kunst 2013; Montero-Ruíz *et al.* 2021; Murillo-Barroso and Montero-Ruíz 2012; Rovira and Montero-Ruíz 2013; Ruíz Taboada and Montero-Ruíz 1999). For copper smelting alone, the evidence in the Balkans pre-dates neighbouring regions as well as those further afield and supports the third model, i.e., the independent invention of metallurgy.

As highlighted in Chapter 3, the smelting of copper ores was not the earliest application of pyrotechnology in either the Balkans or Anatolia. The transmission of ceramic forms and pyrotechnology from Anatolia to the Balkans occurred from *c.* 6600 BC, with ceramic production and consumption subsequently being extensively practiced and developed by early farming communities (Amicone *et al.* 2019; de Groot 2019; Spataro and Furholt 2020). Given that this process started around 1500 years before the earliest evidence for metallurgy in the Balkans or elsewhere, it leads us to the issue of the interdependence of pottery and metal pyrotechnologies (Research Question 2). The key question is whether the ability to create and manage high temperatures (exceeding *c.* 1000 °C) could have led to the transformation of copper ore to copper metal. In their research on the interdependence of pottery and metal technology at the Vinča sites of Belovode (Chapter 14) and Pločnik (Chapter 29) within *The Rise of Metallurgy* *in Eurasia* project, Amicone *et al.* (2020) (Chapter 43) dismissed the importance of high temperatures in pottery firing for proving this relationship in terms of the mastery of the Vinča potters' pyrotechnological skills. Instead, they highlight the more critical skill of controlling firing atmosphere conditions. The production of a functional pot required temperatures only in the range of 600–700 °C, and not in excess of 1000 °C. It is contended that previous scholarship over-estimated the role of firing temperatures in seeking the best fit with the model of interdependence between pottery and metal technologies.

The findings from *The Rise of Metallurgy in Eurasia* project (see Chapter 43) do not, however, preclude that other advances in pyrotechnology, such as mastery of fire control, could not have laid the groundwork for further technological advances such as copper extraction. The only hypothesis from previous scholarship on pottery pyrotechnology that Amicone *et al.* (2020) (and Chapter 43 of this volume) confirmed was that of Frierman (1969) and the two-step process of firing graphite-painted pottery, broadly similar to the two-step process of the earliest metal smelting (Radivojević *et al.* 2010b: 2777). The theories of graphite-rich moulds being used for metal casting used to counteract the oxidation process (Gaul 1948: 98; Ryndina and Ravich 2000: 16–17) remains to be confirmed archaeologically. However the roughly contemporary emergence of both copper smelting and the practice of graphite decoration at the dawn of the 5th millennium BC makes them equally likely to have influenced each other. This is particularly valid for settlements with strong evidence for metallurgical practice and adjacent graphite deposits such as Pločnik, on which Amicone *et al.* (2020) (and see Chapter 43) build their case. Hence, these technologies are rather seen as 'close cousins', clearly impacting each other, highlighting the need for future programs to date the emergence of graphite painted pottery in conjunction with early metallurgy in the Balkans.

It is notable that the emergence of graphite painting and copper smelting technology take place at around the same time as the appearance of a distinct phase of the Vinča culture called 'Gradac' (Vinča B2–C1). This phenomenon has been mainly characterised by the following: changes in pottery styles; house destruction horizons at several sites; an increased number of settlements erected at more dominant positions; the intensification of elaborated monumental figurine production (Garašanin 1991); and the intensification of mining activities at Rudna Glava (Pernicka *et al.* 1993; Radivojević and Kuzmanović Cvetković 2014). This pattern of a shift in some settlement and living practices has been identified across the Balkans at around the same time (Garašanin 1994/1995), prompting Jovanović (2006) to argue that the emergence of metallurgy was the driving force for the observed change. While current research, including this monograph, can certainly confirm that the emergence and intensification of copper metallurgy exhibits *correlation* with the changes in a number of material and dwelling practices, more studies to include dating and archaeomaterials analysis is required to explore the *causation* behind these phenomena across the Balkans (cf. Radivojević and Grujić 2018a).

When this evidence is evaluated against the three models outlined above it can be argued that, whilst the knowledge and practice of selecting copper minerals and the pyrotechnology to make the ceramics derived from early farming communities moving from Anatolia to the Balkans, the smelting of copper ores occurred independently in communities in the central Balkans. The nature of the pyrotechnological pathway that led to the smelting of copper metal remains unclear, as *The Rise of Metallurgy in Eurasia* project has demonstrated that the temperatures and conditions required to create contemporary and earlier ceramics are not transferrable in a straightforward manner.

## Invention, innovation and polymetallism

In a special section of the *Cambridge Archaeological Journal* (Roberts and Radivojević 2015), we argued, alongside other authors analysing ceramics, gold, iron glass and glaze from across the world, that the processes of inventions in early societies could be evaluated in terms of pyrotechnologies. This contrasts with the reluctance of most archaeologists in recent decades to engage with the concept of invention. This is not only due to the partial nature of the archaeological record, which frequently reveals earlier dates for defined phenomena as investigations intensify, but also to the intellectual baggage of technological determinism. The social evolutionary schemes of Lubbock (1872), Morgan ([1877] 1985) and others, whereby 'inventions and discoveries stand in serial relations along the lines of human progress and register its successive stages' (Morgan 1985: vi), casts a long shadow. The continued influence of a classification scheme of technological stages within social evolutionary schemes (cf. Childe 1944) has contributed to this intellectual unease. The more recent exploration of the socially constructed underpinnings of modern understandings of technology and a more in-depth recognition of technology as a socially embedded phenomenon (e.g. Dobres and Hoffman 1994, 1999; Lemonnier 1993, 2012; Schiffer 2001) has reinforced the suspicion that the concept of invention is an anachronism. This suspicion is reinforced by debates over inventions within archaeology that begin with scientific criticisms of the proposed earliest dates for a phenomenon, but can rapidly become mired in academic, nationalist, and post-colonial politics. The danger of drifting into 'Originsland' as eloquently deconstructed by Gamble (2007: 61ff) is ever present.

Invention is frequently defined as the discovery of a new idea, material, or process, deliberately or by chance (cf. Renfrew 1978b). An invention may include a radically new product as much as a recombination of technological components in a novel manner (Basalla 1988; Nelson and Winter 1982; Weber *et al.* 1993). Alternatively, an invention may involve the application of an existing technology to a new purpose (Fleming and Sorenson 2004; Henrich 2010). The three stages of the process of invention (gestation, cradle, maturation) very rarely take place during the lifetime of a single inventor (Lienhard 2006: 165). It could take a few generations of inventors who contribute to accumulation of knowledge before the invention is sufficiently perfected to find a wider acceptance. These contributions are commonly mirrored in a high frequency of failure and unintended outcomes that occur over a period of uncertain length. Therefore, the biography of a past invention would have often started a couple of decades or even centuries before it became visible in the archaeological record. It is also often the case that inventions cannot find any economic use until other ideas that are yet to be discovered render practical what was once considered a 'long shot' (Wiener 1993: 145).

It has been frequently argued that when an invention affects the evolution of the system and is successfully transmitted within a population, and beyond, it is recognised as an innovation (e.g. Henrich 2001; O'Brien and Shennan 2010a; Ottaway 2001; Renfrew 1978b, 1986; van der Leeuw and Torrence 1989). A technological innovation is not usually only a monolithic entity, but an 'amalgam of units', or a 'recipe' containing ingredients required to make an object (Lyman and O'Brien 2003; Mesoudi and O'Brien 2008; Neff 1992, 1996; O'Brien and Shennan 2010b). In a technological context, this recipe is a list of what, how, and when to make something, and for how long (Krause 1985).

Michael Schiffer (2005, 2010, 2011) proposes a more nuanced definition of invention, arguing that invention is 'the creation of an idea or vision for a technology that has performance characteristics—often use-related ones—differing from those of other technologies' (Schiffer 2011: 36). The emphasis on invention as the *idea*, rather than the materialisation of the idea, is more common within industry and commerce where 'invention is the first occurrence of an idea for a new product or process, while innovation is the first attempt to carry it out into practice' (Fagerberg 2004: 3; see Schumpeter 1939). However, there remain disagreements within these disciplines, as there are within archaeology, as to whether invention should also encompass the realisation of the idea (e.g. Rogers 1962, 2003; contra Wiener 1993). Similar ambiguities and debates in the definition and evidencing of an invention also underlie the development of modern patent law (Pottage and Sherman 2010). Indeed, the intellectual history of the terms 'invention' and 'innovation' reveals ever-shifting definitions, meanings and applications relating to the societies in which they were used (Godin 2015).

The archaeological record reveals the materialisation of ideas and therefore, from this perspective, the innovations rather than the inventions (see Jones 2004; Ingold 2007; Lemonnier 2012; Malafouris 2013; Meskell 2005; Miller 2005; Renfrew *et al.* 2005). However, it is argued that the time-depth of the archaeological record can, with sufficient data resolution, provide the possibility of investigating the accumulation of knowledge or process components preceding and underlying the invention of a particular technique or material. These would be observable through experiments, re-combinations, or re-applications (to a new purpose) over a period of several decades, centuries or millennia (Basalla 1988; Henrich 2010; Lienhard 2006; Weber *et al.* 1993). Taking invention as the appearance of a new idea, process or material, the differentiation between an invention and an innovation within pyrotechnologies is potentially far less ambiguous than in other aspects of past human activities in the archaeological record. The conceptualisation of invention as a process—rather than a singular event—as has been extensively explored in archaeology by Schiffer (2005, 2010, 2011: 57–85) for mainly modern technologies. Invention and innovation in archaeological interpretative models, including those relating to the origins of metallurgy, have also been critically re-evaluated more recently by Frieman (2021). These more nuanced approaches enable the anomalies to be placed within the choices and sequences of transformative actions underlying pyrotechnology. The selection of black-and-green copper ores for smelting as opposed to the pure green minerals for decoration by communities in the Balkans represents not only a process of invention, but one in which choices and sequences can be identified.

Given the presented evidence, while the practice of sourcing copper minerals and native copper originated outside of the Balkans and was brought into the region—presumably accompanying other broadly contemporary materials that were being exploited such as obsidian—the development of copper metallurgy took a technologically distinctive and independent route in the Balkans from as early as 6200 BC (Radivojević 2015). The very moment of 'invention', though, is difficult to pinpoint but is certainly not later than 5000 BC, when we already see the developed and repetitive process of smelting under similar redox conditions and with similar 'recipes' across the Vinča culture sites (Radivojević and Rehren 2016). From this perspective, the invention of copper metallurgy could have taken place any time between 6200 BC and 5000 BC, but most likely during the second half of the 6th millennium BC.

### But what was the process of invention of copper smelting?

Prior to *The Rise of Metallurgy in Eurasia* project, Radivojević and her colleagues had shown, in extensive analytical studies across the Neolithic and Chalcolithic Balkan sites in recent years (Radivojević *et al.* 2010a; Radivojević and Rehren 2016), that the use of copper minerals for decorative purposes and for copper smelting involved different selection practices and intent based on colour. The identification of dual selection (pure green copper minerals vs. black-and-green copper ores) not only indicated aesthetic differences, but also varying compositional requirements, implying that copper smiths distinguished between the material properties of differently coloured minerals. Such a technological practice and clear distinction between minerals for ornaments and those for smelting has not yet been identified in Anatolia or in the Near East. This was the foundation of Radivojević's (2012, 2015) claim that the preference for the black-and-green appearance in the selection of copper minerals by Late Mesolithic/Early Neolithic communities in the central Balkans from *c.* 6200 BC prompted early experimentation and subsequent copper smelting. This selection process is particularly evident in the abundance of manganese oxide in the post-5000 BC Vinča culture copper slags, which is known to facilitate the formation of a melt under the variable redox conditions that one would expect from hole-in-the-ground smelting installations (Huebner 1969: 463; Radivojević and Rehren, 2016: 221 ff.).

The results from *The Rise of Metallurgy in Eurasia* project, which recorded the extensive presence of copper minerals throughout the entire sequence of Belovode and Pločnik, demonstrates that the hypothesis on consistent selection of black-and-green copper minerals holds up for the newly discovered workshop (F6, see Chapter 11), while malachite beads show a mixed picture of selecting pure green and black and green minerals for decorative items. These results, however, reinforce the major tenet of the claim for the independent evolution of Balkan metallurgy: Vinča culture communities were intentionally selecting black-and-green copper minerals for copper smelting over the course of 600 years, and these were sourced in eastern Serbia, uniquely for all early copper smelting sites across Serbia and Bosnia (Chapter 41). While the exact locations of these deposits are not certain, we know that they are multiple to begin with, and contain cobalt and nickel mineralisations that have, incidentally, already been detected in the ancient mines of Rudna Glava and Majdanpek (Pernicka *et al.* 1993). Even though the pursuit for these deposits remains a task for the future, the results of *The Rise of Metallurgy in Eurasia* project reinforce previous analytical investigations (e.g. Radivojević and Grujić 2018a; Radivojević and Kuzmanović Cvetković 2014; Radivojević and Rehren 2016) by providing a higher resolution of insight into the connectedness of the early copper metal making Vinča sites and local deposits, as well as their networks of supply across the Balkans.

The selection of lead ores and the application of pyrotechnology to them, evidenced from the *c.* 5200 BC lead slag 'cake' at Belovode (Radivojević and Kuzmanović Cvetković 2014) and the use of lead ore for beads at Autoput, Selevac and Opovo in Serbia and Donja Tuzla in Bosnia—in all cases in horizons that end in 4500/4400 BC at the latest (Glumac and Todd 1987; Quitta and Kol 1969; Vogel and Waterbolk 1963), as detailed in Chapter 3—is too often overlooked. This is particularly valid when claims for the 'new earliest' are made, as with lead ore processing in Pietrele, which emerges *after* the end of the Vinča culture (Hansen *et al.* 2019). It is, however, evident that the knowledge, pyrotechnological experiments and establishment of craft and material practices surrounding vibrantly coloured minerals and later ores, whose metallurgical properties could only have been distinguished by their colours (black, green, blue and violet), were fundamental during the centuries spanning *c.* 6200–5000 BC (Radivojević 2015).

A consequence of the colour preference in (complex) copper ores is the tin bronze foil (Pločnik 63), as detailed in Chapters 3 and 6. Excavated from an undisturbed context, on the floor of a dwelling structure next to the likely copper metal workshop at the site, about 1 m from a fireplace, the foil was enclosed in several late Vinča culture pottery vessels (Radivojević *et al.* 2013: 1033, Figure 2). This securely contextualised find comes from a single, undisturbed occupation horizon at Pločnik, dated to *c.* 4650 BC. This date is, according to the field evidence, the *terminus ante quem* for the Pločnik foil at present. The composition indicated that stannite [$Cu_2FeSnS_4$], a copper-tin bearing mineral, was the probable ore used for making this natural alloy with *c.* 12wt% Sn and relevant traces of As, Fe, Co and Ni (see Radivojević *et al.* 2013: 1035, Table 1). As detailed in Chapter 3, there are 14 additional tin bronze artefacts known from the mid-late 5th millennium BC Serbia and Bulgaria; however, these finds only occurred together in what appears to be a short-lived tin bronze horizon in the Balkans based on geochemistry that links them with the Pločnik foil.

When the Pločnik foil date is evaluated against the earliest evidence for tin bronzes in Europe, Anatolia, and Asia (Pigott 2011; 2021; Rahmstorf 2011; Radivojević *et al.* 2013), claims from two discoveries require detailed consideration. These are the assertions about the 6th millennium BC emergence of naturally alloyed tin bronze artefacts from the sites of Tel Tsaf in Southern Levant (Garfinkel *et al.* 2014) and Aruchlo in Georgia (Hansen *et al.* 2012). The Tel Tsaf metal awl was discovered in a secondary context (burial in a silo) in what is currently claimed to be a largely Middle Chalcolithic horizon, broadly dated to between 5100 and 4600 BC. The authors ascribe the metal awl to the late 6th millennium BC (Garfinkel *et al.* 2014), despite the fact that: a) the skeletal burial had enough datable materials available between the individual and the rest of the burial offerings; and b) even if the secondary context is truly Middle Chalcolithic, its characteristics are more indicative of the end of the silo's use-life, at best, 4600 BC. The analysis of this heavily corroded awl 'with no original metal left' (Garfinkel *et al.* 2014: 3), conducted with portable ED-XRF, implied an Sn content between 3.5wt% and 7wt%. While the authors acknowledge that these figures may be overestimated given that tin is known to be relatively immobile in most burial conditions compared to copper and hence usually found enriched in corroded layers, the questions remain: how much tin was there, and was it enough for the smiths working with it to detect any difference in the performance of the artefact, or in its colour?

Comparative analysis of tin bronze artefacts using handheld XRF and EPMA (Electron Probe Micro Analyser) indicate that the former technique can differ around 20% from the true metal body values when applied to the metal surface cleaned from corrosion, or *c.* 70% or more when performed on the corroded surface of the same object (Orfanou and Rehren 2015). Although we do not know exactly the effect of the burial deposits on the enrichment of tin in the Tel Tsaf artefacts, estimates based on the reported XRF analysis in Garfinkel *et al.* (2014: 4, Table 1) indicate that the true value of tin content in the Tel Tsaf awl could potentially be between *c.*1wt% and 2wt%. While this is a speculative calculation with many unknowns, with such a composition the Tel Tsaf awl would still qualify as a tin bronze but without any indication of intentional alloying, which is a key factor for the foil from Pločnik in Serbia. The colour range of the awl would barely differ from that of common contemporary copper artefacts, even with up to *c.* 5wt% of Sn content (see Figure 6, Chapter 3 this volume), which suggests that the process of its making, if truly contextualised towards the end of the Middle Chalcolithic, probably made no difference to its appearance at the time. In addition, the performance of the awl would be dependent on the reduction in thickness by working, which is unknown due to the lack of any preserved metal body. The Aruchlo bead from the Neolithic site in Georgia is also optimistically set too early in the date range (5800–5300 BC). The handheld XRF analysis of this heavily corroded item with no metal body preserved reveals a compositional structure of what looks like predominantly malachite mineral with relevant impurities of tin, arsenic and iron, which are comparable with the polymetallic mineralisations in that area (Bastert-Lamprichs *et al.* 2012; Hansen *et al.* 2012). In sum, the claims for the early tin-bronzes in the Levant and Georgia in the 6th millennium BC require more rigorous analytical probing in order to substantiate their currently published interpretations. There is therefore no compelling evidence that either the idea or the technological expertise for the tin bronzes in the Balkans derived from communities or networks beyond this region.

In order to understand the why there is a tin bronze foil at Pločnik at *c.* 4650 BC, it is instead necessary to understand the impact on copper of major impurities such as tin, arsenic and antimony. The resulting metals not only melt at lower temperatures than pure copper objects and are easier to cast (Lechtman 1996; Northover 1989;) but also transform their colour into different shades of bright yellow, whose range has recently been experimentally demonstrated (Radivojević *et al.* 2018b). The key, however, is the use of black-and-green copper-based ores, such as stannite, which is argued as the starting point of experimentation with the new metal in the Vinča culture context (Radivojević *et al.* 2013). It is possible that this colour selection process meant the exclusion of grey-coloured copper fahlores, such as tennantite and tetrahedrite, whose successful smelting would have produced arsenical copper, a metal that is not present in the Balkans until the mid-4th millennium BC (cf. Chernykh 1978b; Pernicka *et al.* 1997; Radivojević *et al.* 2010a). Nevertheless, there are indications for the use of hydrated iron-arsenates, such as the green/blue scorodite [$FeAsO_4{\cdot}2H_2O$], which precipitates from the primary ore of arsenic, arsenopyrite [$FeAsS$], in the copper smelting process in Gornja Tuzla (Radivojević and Rehren 2016: 219, 225 ff, Figure 7h). This rare occurrence of utilising arsenic-rich ores has been convincingly argued to be due to the selection of an attractive mineral colour, which is admittedly the same rationale for selecting stannite for making tin-bronzes in Pločnik. Given the highly experimental nature of early metal technology in the Balkans being, we may see more arsenic present in the copper smelting process in future excavations, even if only as a colourful addition to the smelt.

As detailed in Chapter 3, the appearance of thousands of small decorative objects made of gold also dates from the mid-5th millennium BC in northeastern Bulgaria, southeastern Romania and northern Thessaly (Higham *et al.* 2007; Krauss *et al.* 2017; Makkay 1991). Although the gold from the cemetery of Varna I is claimed as the earliest known (dated most recently between 4690 and 4330 cal. BC) (Krauss *et al.* 2016), there are earlier uses of gold ornaments (although not as securely dated) in the Varna II cemetery (Todorova and Vajsov 2001: 54), as well as in the cemetery of Durankulak (Avramova 2002: 193, 202, Table 24; Dimitrov 2002: 147). The earliest gold from beyond the Balkans is in the form of eight gold and electrum rings from Nahal Qanah in the southern Levant, dating to the late 5th millennium BC (Gopher and Tsuk 1996; Klimscha 2013) with all other finds across Europe, Anatolia and Asia dating to the 4th millennium BC or later (Meller *et al.* 2014); there is no evidence for an external transmission of the idea, technology or metal into the Balkans. Colour manipulation is revealed in the carefully controlled alloying of copper with gold to create a specific colour palette from *c.* 4550 BC at Varna, Bulgaria (Leusch *et al.* 2015). As Radivojević *et al.* (2013) originally proposed, the mid 5th millennium BC sees a polymetallic horizon in the Balkans which is driven by a desire for specific colours and pyrotechnological experimentation. These metallurgical inventions and innovations were, as was long ago recognised by Cyril Stanley Smith (1981), motivated more by cultural aesthetics ('desire to beautify') than efficient functionality.

## Early metals, metallurgies and societies

Despite scholarly critiques for over a century, the Four or Three Age system—depending on which scholarly tradition is followed—remains firmly embedded. The emphasis on the transition from stone to metal technologies, as identified across the majority of Europe, North Africa and Western Asia by a Copper, Eneolithic or Chalcolithic Age (cf. Pearce 2019), has often ensured that the appearance of metallurgy is connected to broader political, social and technological changes (Roberts and Frieman 2012; Schier 2014a). The influence of modern value systems mean that early metal and metallurgy was inevitably ascribed a high value by scholars relative to other contemporary artefacts and technologies in other materials. As reviewed extensively in Kienlin (2010) and in Chapter 3, the direct consequence was that, even prior to the discovery of early metal production evidence, specific interpretative narratives of metals and societies rapidly became embedded in scholarship. Drawing on the pre-existing evidence as well as new evidence from *The Rise of Metallurgy in Eurasia* project, this section addresses not only Research Questions 1, 3, 4 and 6 on the organisation of early metal production in the Balkans but subsequently re-evaluates the interpretations around early metallurgy and metal, and their relationships to the societies involved.

### Sourcing ores

The extensive provenance dataset dating from the 5th millennium BC in the Balkans (cf. Pernicka *et al.* 1993, 1997; Radivojević *et al.* 2010a; Radivojević and Grujić 2018a), paired with fresh analysis of materials excavated within the remits of *The Rise of Metallurgy in Eurasia* project (see Chapter 41) largely confirmed the previous indicators for the sourcing of copper ores during this period. The higher resolution approach to exploring the early copper supply routes in the Balkans highlighted two important points: a) the significance of several east Serbian copper deposits (some yet unknown) for the early phase of metallurgy evolution in the Balkans (Early Chalcolithic, *c.* 5000–4600 BC), and b) the super-connectedness of metal producing and consuming sites in Serbia, Bosnia and Bulgaria, along important communication routes.

Both lead isotope and trace element analyses (Chapter 41) of metallurgical materials from Belovode and Pločnik reveal the complex dynamics of copper acquisition routes between *c.* 5200 BC and *c.* 4450 BC in the Balkans. Overall, the Balkan Chalcolithic communities were utilising copper from at least six (or seven) copper deposits, two of which are still unidentified. These are: Majdanpek, Ždrelo, Ai Bunar, Medni Rid, 'Group of 16', 'Cluster #8' and potentially Rudna Glava (or an associated Co/Ni rich mineralisation). Of these, Vinča culture communities were not using metal from Bulgaria's Medni Rid, while Ai Bunar's copper has only been used during the extended occupation of Pločnik, or beyond *c.* 4600 BC. While these deposits were identified based on most artefacts clustering in distinctive groups, the list is not exhaustive.

Of particularly interest were the consistencies of trace elements with metal production evidence from Rudna Glava, the earliest dated copper mine in the world thus far, with *c.* 5500 BC being the proposed date for the start of mining activities at the site. Although the mine has confirmed signs of Vinča culture mining (Jovanović 1980), no copper metal artefact has yet been confirmed to come from this mine. This is despite the partial consistency of metal production evidence (slags from Belovode, Vinča and Gornja Tuzla), with the best match regarding Co/Ni content amongst the known copper deposits in east Serbia. For future research, it would be important to analyse Ždrelo ores for trace elements and pursue similarly rich Co/Ni mineralisations in the region which, altogether, may offer clearer pointers as to which deposit (or deposits) provided the black-and-green copper ores that were consistently smelted in the Vinča culture sites (cf. Radivojević and Rehren 2016).

Regarding the interconnectedness of these early metallurgical sites, the direct $^{14}$C dating of materials associated with metallurgical materials from Belovode and Pločnik provided, for the first time, high-resolution evidence of the beginning, evolution, and end of metallurgy in these settlements and, most importantly, data on the cooperation between these communities concerning access to copper ores. For instance, the close consistency of Belovode production evidence with copper implements from Pločnik, or similar correspondence of copper minerals from the earliest levels in both sites pinned to the 51st century BC, reinforces the assumption of their close connectedness and involvement in sharing metallurgical knowledge. Equally, the matching data from smelted copper in one horizon and malachite associated with another in Belovode speaks to the presence of consistent supply networks throughout the occupation of this settlement. Both of these sites exhibit more connections with Vinča and Gornja Tuzla, indirectly or directly, as well as along the lower Danube route, which was highly important in the exchange of metallurgical knowledge and/or ores and artefacts.

## Making metals

What, then, did the copper smelting process look like in the first 500 years of this practice in the Balkans, based on current analytical and field evidence? In the absence of any other smelting installations, the current model of metal production inferred from the hole-in-the-ground 'furnaces' (cf. Radivojević and Rehren 2016; Rehren *et al.* 2016), including F6 in Belovode elaborated here (Chapter 11), speaks to the large quantity of extant copper metal artefacts being produced in multiple individual episodes. These smelting episodes could have been made more efficient if many were undertaken simultaneously, within each (or between many) participating household or, more precisely, within one or many of the backyards of individual dwellings, as this was an outdoor operation. The production efficiency would depend upon the smelting charge (ores + fuel) and the ability to maintain the redox conditions. While the final result could be anywhere between tens and hundreds of grams of copper metal, it is unlikely, based on the current evidence, that the heavier (1 kg plus) copper implements were produced in a single smelt. The fragmentary evidence of melting crucibles in Bulgaria and, possibly, Romania, suggests that this metal was remelted and cast (Rehren *et al.* 2020; Ryndina *et al.* 1999; Stefan 2018). We can observe evidence for the latter only from metallographic examination of as-cast objects (Kienlin 2010).

In 2013, during the excavation campaign at Pločnik, the first author ran series of smelting experiments based on these early reconstructions of metal extraction process and, with her team, managed to successfully smelt copper from local ores. One clear outcome of these experiments (the full account is currently outside the remit of this paper) is that, in order to be successful, the process demands a community of people working together in a range of co-ordinated roles (Figure 1). Six people were required to operate six blowpipes with ceramic nozzles on their tips (see Figure 4e-f, Chapter 3). These individuals were regularly replaced, as fresh blowers were needed every 15–20 minutes in a process that, on average, lasted 60 minutes. Meanwhile, a seventh member of the smelting crew ('master smelter') was engaged in maintaining the fire or regular charcoal charge. An additional, critical, member of the team was – a drummer! Well-paced and uninterrupted air blowing into the 'furnace' was crucial for the success of the smelt, ensuring that the desired temperature was reached at a rate that prevented the copper metal ending up in the slag. With a large group of people participating, it was impossible to maintain the air flow without a unifying rhythm. This phenomenon has also been observed in

Figure 1. a) Copper smelting experiment in Serbia in 2013 aimed at reconstructing the earliest metal extraction process based on archaeological and laboratory reconstructions. Note six blowers, one drummer and one master smelter (upper left), with two people in the back waiting as a replacement for the blowers; b) Ideal reconstruction of the hole-in-the-ground smelting installation from the site of Belovode in Serbia. (Photo CC BY-NC-ND 4.0 J. Pendić and M. Djurica @Reuters).

experimental reconstructions of African iron smelting, where drums were used to regulate the use of bellows (cf. Chirikure 2010; Humphris *et al.* 2018).

These smelting experiments prompt us to consider how control of the smelting knowledge was exerted, if at all, and how the personal relationships between the many participants shaped the smelting technology. They also raise the question of how strict the replication of the 'recipe' could had been in this environment, and whether the variations that we see in the composition of colourful ores used for copper smelting (Radivojević and Rehren 2016) could be explained by human factors, such as trial and error processes. The experiments also prompt other questions: how was trust developed and what kind of ties or rituals were connecting the participants in the metal production process? In the absence of any indication showing this was a full-time occupation, were they all members of a specific group within a community which co-operated specifically for metallurgy (a 'cooperative'?), or simply a mix of family, neighbours, and friends helping each other during the metalmaking 'season'? Given the scarcity of evidence for any hierarchical structure in the Balkan Chalcolithic communities (cf. Porčić 2019a), what is the likelihood that they were organised as a collective grouping – with everyone given equal decision-making power? As Iles (2018) has convincingly demonstrated in her ethnographically informed study of the social landscapes of iron metallurgy in Africa, globally influential interpretations that invariably portray African metal smelting as a secret and exclusively male activity, do indeed stand up to detailed investigation. Future exploration of these nuances in both fieldwork and laboratory settings will allow us to gain more insight and reveal a more complete picture of how past smelters operated and interacted within the boundaries of their personal, social and environmental surroundings.

Why do we not see these hole-in-the-ground 'furnaces' in the field, other than through the indirect evidence, such as slagged pre-fragmented lining sherds (Figure 4c-d, Chapter 3)? Figure 2 shows that these structures are hardly recognisable only nine months post-smelting, although this assumes that the 'furnace' is used only once, which may not have been the case in the past. Nevertheless, these structures are ephemeral by the very rapid nature of their construction: in our experimental case it took a maximum of 30 minutes to dig a shallow hole and line it with sherds, potentially with the addition of clay as a binder. These smelting installations were clearly not intended to be durable, but rather to be ready for operation in a relatively short time. As such, they could have been built anywhere on or off the settlement site, the only evidence of their existence left for subsequent archaeologists being the ores, slags, slagged sherds and potentially metal artefacts.

This brings us to the question of how many smelting installations or 'workshop areas' we can estimate were present, based on the current evidence. In the case of Belovode or Pločnik, both of which we studied in detail and excavated, it seems very likely that that every household produced some metal in their backyard or communal area. This is corroborated by the extensive evidence for hundreds of copper ores found in every context, every feature, every dwelling, and every communal area across both sites (see Chapters 5, 6, 11, 26 and 41). These were predominantly manganese-rich, black-and-green copper ores, which we know were used for copper extraction (cf. Radivojević 2015). Slag and slagged sherd finds were notoriously rare at both sites (and beyond) prior to *The Rise of Metallurgy in Eurasia* project and its targeted methodological approach, however an excavation recovery bias must be taken into account: slag is essentially dark grey or brown, and small, crushed samples are not discernible

Figure 2. a) Installation from Figure1b post-smelting; b) Installation from Figure1b after 9 months. (Photo CC BY-NC-ND 4.0 J. Pendić and M. Radivojević).

in the soil. A salutary lesson on their potential invisibility to the excavator is that the small, less than one gram per sample, copper slags at Belovode were only identified in the field because they included some remaining copper metal with green patination (Radivojević *et al.* 2010a: 2779). These finds were held for 14 years at the National Museum in Belgrade in a box mislabelled 'copper minerals' because, at the time, nothing was known about the copper smelting in the Vinča culture save for how these early slags might have appeared. This experience highlights the need to include magnets (to detect Fe-rich slag matrix) and sieving as regular practice in future excavations targeting Chalcolithic sites in the region and beyond, otherwise evidence for early metallurgy could easily be missed.

The widespread presence of copper ores at Belovode and Pločnik calls for a different interpretation of metallurgical activities at these sites, with implications for other sites with similar evidence. We would argue that the pursuit by archaeologists of an early metallurgy specialist 'workshop' and an individual 'smith' reflect a romanticised—even mythological—ideal that may resonate in Childean narratives but is simply not reflected in the reality of the archaeological and archaeometallurgical evidence. With high-resolution fieldwork integrated with laboratory analyses and experimental reconstructions, a very different perspective emerges.

This new interpretative framework for Vinča culture metallurgy comprises:

1) multiple production episodes due to the limited scope for mass production using the hole-in-the-ground 'smelting installations' or furnaces;
2) collective and co-ordinated actions by groups of people, from the acquisition of the ore through to the production stages;
3) community-wide accessibility to the knowledge and practices of metal production; and
4) the absence of a single 'specialist smith'- due to lack of evidence.

On this last point, there is a lack of differentiation in the general material culture assemblage in the excavated dwelling features. In addition, even at the Varna 1 cemetery, Leusch *et al.* (2017) argue convincingly that there are considerable challenges to any confident identification and interpretation of a given grave as specifically belonging to a metalworker, whether through the associated artefacts or by osteological analyses. In further support of this notion, papers in Brysbaert and Gorgues (2017) demonstrate that the interpretations of a specialist craftsperson's societal identity in European prehistory through the evidence of their crafting activity are diverse and complex – showing that there can be no straightforward analogy with ethnographic case studies from other continents or myths from other societies emphasising the separation and status of the smith (cf. Budd and Taylor 1995).

The results from the excavations at Belovode and Pločnik emphasise instead the spatial, material, and technological integration of craft activities that encompasses the contemporary production of ceramics, polished stone tools, flint blades and metallurgy by individuals and groups, all within the broader settlement context at each site. The creation and/or shaping of these inorganic materials also occurred within the vicinity of cereal processing, animal butchery and other food production activities. There is no straightforward distinction between what might be classified as specialist as opposed to non-specialist craft activities either at Belovode or Pločnik or in the broader discussions of craft activities in the Central Balkans during the late 6th to 5th millennium BC (Chapters 45, 46, 47, 49). As highlighted by several scholars (Kuijpers 2018: 231–237; Molloy 2008: 174; Molloy and Mödlinger 2020), there is a difference between a specialisation (i.e. a skill at a specific activity) as opposed to a specialist (i.e. a person who is focussed exclusively on a specific craft or activity) and, as will be argued below, with the possible exception of elements of Varna goldworking (Leusch *et al.* 2015), that a community with specialisations rather than individual specialists underpinned craft production in the Balkans during the 5th millennium BC.

## Using and depositing metals

The excavations at Belovode revealed 12 copper mineral ornaments, two copper metal droplets and one fragment of a finished copper metal artefact (see Chapter 11) whilst the excavations at Pločnik yielded 13 copper mineral ornaments, one copper metal droplet and fragments of five finished copper metal artefacts (see Chapter 26). The copper metal artefacts, like the minerals, are—where it is possible to identify a form—small, ornamental, and, as beads and rings or bracelets, apparently designed to adorn the human body. Given the archaeological contexts in which they were recorded, they have been analysed and interpreted within the context of copper production and circulation (see Chapter 41). Their fragmentary condition means that, whilst the copper mineral/metal objects may well have had an extensive use-life, as for instance with the loop or ring (C_P1/13) and bracelet or wire (P13/13), no current wear trace analysis approach (Dolfini and Crellin 2016) would be able to identify this.

Yet, the presence of these small ornamental copper metal and mineral artefacts raises two important considerations: 1) the recycling of copper; and 2) the types of objects being produced. Regarding the former, it is currently not possible to determine the extent of recycling as a practice during the 5th millennium BC in the Balkans. The recorded copper artefactual evidence from the region—estimated by Ryndina (2009) to be *c.* 4,300 artefacts but likely to be higher (Chapman and Gaydarska 2020)—is neither a reliable indication of the extent of copper production nor of recycling (Taylor 1999). The archaeological and archaeometallurgical evidence at Belovode, and especially at Pločnik, implies that the recycling of copper metal objects most likely occurred, even in the broader sense of mixing metals, repairing etc. When placed in the broader context of the compositional evidence and network analysis (see Chapter 41), the recycling that did occur must have been within, and not across, identified networks of supply. These supply networks have been extensively discussed in previous research (Radivojević and Grujić 2018a), where it has been convincingly shown that the complexities of copper supply (be it from a single or multiple sources), include a high degree of cultural homogeneity. Each of the connected communities, i.e., the cultures or horizons labelled on the basis of spatially and temporally coherent material culture and/or settlement practices (e.g.,Vinča, KGK VI or Bodrogkeresztúr) stuck to their own trusted sources of supply and acquisition. This kind of regularity in supply chain resulted in artefacts with similar chemical composition clustering within so-called 'modules'; these modules ultimately display either a consistent smelting of the same type of copper ores, or a homogenisation effect as a result of recycling ores from multiple resources but *within* a module (or an archaeological culture as data demonstrated). Hence, if we take this homogenisation effect to reflect a potential recycling practice, it was an activity that followed the same community-orientated connections and practices as the primary production of metal objects.

Regarding the second issue—the nature of the copper objects being made—the debates surrounding copper artefacts are dominated by the discoveries and analyses of large axes, especially during the second half of the 5th millennium BC to which the majority of those recovered are dated. As recently highlighted by Chapman and Gaydarska (2020), the depositional patterns of copper objects are dominated by large tools found in the landscape beyond settlements. This, at least partially, reflects a major recovery bias with small ornaments far less likely either to survive or to be readily identified when compared to large copper tools invariably found as 'chance discoveries' in the landscape. The near absence of an archaeologically visible funerary practice across the Vinča culture (see Chapter 4), where copper ornaments may have been worn, as evidenced at Gomolava (Stefanović 2008), means that it is primarily in excavations of settlement sites that copper ornaments are found and recorded. However, without a detailed and systematic methodological approach such as that undertaken by *The Rise of Metallurgy in Eurasia* project, it is possible that small ornaments could have been missed. For instance, the excavations at Belovode resulted in the first discovery of a copper metal object at the site despite *c.* 15 years of earlier excavations employing a different fieldwork approach. It may also be the case that copper ornaments were more widely recycled by Vinča communities and that it is fragmentary evidence of this wider practice that has been uncovered. Nonetheless, it seems very probable that early copper ornaments were far more widely made, circulated and worn than has previously been appreciated.

## Interpreting metals

The interpretation of early metals and metallurgy in any region around the world must contend with narratives that were frequently well established in scholarship prior to the discovery of any clear supporting archaeological or archaeometallurgical evidence, as highlighted in Chapter 3. To re-cap from Chapter 3, these are:

1. The knowledge and expertise relating to production of metal represented a technological revolution.
2. The knowledge and expertise relating to metallurgy was restricted to specialist individuals who practiced in relative secrecy and held a distinct and elevated status.
3. The properties of metal objects—whether hardness, lustre and/or colour—ensure that they are fundamentally and consistently desirable and valuable to the predominantly farming communities.
4. The production, circulation and consumption of metals was integral to the creation and maintenance of elite status and identity in farming communities.
5. The invention and/or innovation of metallurgy impacts significantly upon the social, political and ritual lives of the farming communities.

Each of these dominant narratives will be critically evaluated against new and previously existing evidence with the underlying aim of building a new framework of interpretation from the primary data, i.e., 'bottom-up', rather than from long held theories, or 'top-down'.

### *1. Technological revolution?*

Perhaps the most pervasive narrative is that the earliest metallurgy represents a technological revolution that is comparable to the domestication of plants and animals or the emergence of cities – influentially termed the

Neolithic and Urban revolutions respectively by V. Gordon Childe (1936). As has been highlighted in the extensive debates surrounding the conceptual and archaeological complexities of these latter phenomena, especially with respect to southeastern Europe (Chapman 2020a; Gaydarska 2017; Gaydarska *et al.* 2020; Ivanova 2020; Shennan 2018; Porčić 2019a; Whittle 2018), defining what might constitute a technological revolution is not straightforward. From a pyrotechnological perspective, it is argued to mean going beyond the 'deliberate processes utilising the control and manipulation of fire' (McDonnell 2001: 493) or more simply 'the use of fire as a tool' (Bentsen 2013) to enable the transformation of matter. This requires a shift in the community perception of the natural environment, as specific rocky outcrops, riverbanks and coasts are newly understood and exploited for the appropriation of raw materials in pyrotechnological processes (Boivin and Owoc 2004).

The concept of extractive metallurgy, just as any other *idea*, had multiple origins. In addition to other places, it found fertile ground to develop within the Vinča culture phenomenon. It evolved through *experimentation*, demonstrated by the presence of black-and-green minerals and 'slagless' extraction prior to the earliest documented smelting, but also by the selection of compositionally different yet similarly coloured ores. The Vinča culture metalworkers also developed an *understanding* of the smelting process and applied it in a consistent manner throughout the centuries of practice. The Vinča culture communities must have had social institutions in place to provide *logistics* for the distribution of metal implements to markets that desired these objects. Metallurgy *de facto* transforms the matter and is, as such, the first pyrotechnology with completely transformed products. The road to this invention is clearly demonstrated in the shift in the sourcing, collection and use of copper minerals for decoration and use of copper ores (minerals smelted to gain metal) to produce metals by communities in the Balkans. However, given that copper smelting was preceded by the pyrotechnological production of ceramics (de Groot 2019) and paralleled by the production of graphite-painted pottery (see Chapter 43), to what extent does it constitute a technological revolution of the kind that is expected to create a major and immediate impact upon societies?

Given the small-scale characteristics of metal production in evidence for the first half millennium across the Balkans, it is only with the hindsight of the metallurgical developments that would, several millennia later, impact upon world history, that this initial development could be viewed as revolutionary. In a seminal and highly influential paper, Budd and Taylor (1995) argued strongly for early metallurgy in Eurasia to be understood within an interpretational framework that drew on anthropological ideas of ritual and magic rather than the application of modern industrial and technological standards. Whilst the social evolutionary concepts of V. Gordon Childe can certainly be abandoned, it will be argued below that their replacement by a 'ritual' interpretation is contradicted by the archaeological and archaeometallurgical evidence.

### *2. Special smiths?*

The 'metal smith' of later prehistoric Europe has been variously interpreted in scholarship as 'nomadic, a reviled outsider, elite in status, a mediator of wealth, a shaman or a proto-scientist' (Molloy and Mödlinger 2020: 169; cf. Eliade 1962), in a debate that primarily concentrates upon evidence from the European Bronze Age. Once again, the influence of V. Gordon Childe can be felt due to his interpretation of itinerant smiths whose movements between tribes were responsible for the diffusion of new ideas, technologies, and practices (Wailes 1996; Trigger 1986). Subsequent critiques of 'Childean smiths' have emphasised issues including the lack of ethnographic parallels, the over-emphasis on full-time specialisms, the lack of a ritual framework, and the need to incorporate kinship (Rowlands 1971; Budd and Taylor 1995; Kienlin 2010; Rowlands 1971).

The identification and interpretation of the 'smith' in the European Chalcolithic and Bronze Age is far from straightforward. Major surveys of the funerary evidence thought to constitute 'metalworkers graves' by Jockenhövel (2018) and Nessel (2012; 2013) – neither of which encompass the Chalcolithic in the Central or East Balkans – have consistently highlighted the complexity, ambiguity and rarity of compelling evidence. When evaluating an extensive range of evidence for smiths across Later Bronze Age Europe (1500–800 BC), Molloy and Mödlinger (2020) argue persuasively that metalworking was widely practiced and embedded within, rather than isolated from, the social lives of the communities involved. This is also the conclusion reached by (Găvan 2015) in her analysis of metal and metalworking evidence found in the Bronze Age Tell Settlements from the Carpathian Basin (c. 2500-1500 BC). The evidence excavated at Belovode (Chapter 14) and Pločnik (Chapter 29) implies that this integration of metalworking and community life occurred from the earliest metallurgy.

The only potential evidence for an identifiable 'smith' in the Balkans during the 5th millennium BC lies in the re-interpretation of the famous 'prince' from Grave 43 at Varna, who should now be more appropriately designated a 'smith', buried with his range of tools, including the mis-interpreted penis foil (Chapter 3). It is perhaps not coincidental that it is in Varna where the techniques of gold production, such as gold alloying, lost wax casting and gilding, are technologically unparalleled across the Balkan region (cf. Ivanov 1988a; Leusch *et al.* 2014, 2015). Yet these rare and complex specialisms in gold technology need to be understood, not only in the light of far more widespread metallurgical specialisms across the Balkans (see Chapters 3 and 41), but also alongside other archaeologically identifiable specialisms in other inorganic and organic materials, domestic plant and animal management, and settlement construction (Chapman 2020a). The widespread evidence for archaeologically visible *specialisms* across the communities in the Balkans, let alone those that are far more difficult to discern in the archaeological record, should be distinguished from the presence of *specialists* (Kuijpers 2018) where the evidence in any material or practice is far more limited. Within this broader perspective of specialisms throughout small-scale farming communities, the relationship between 'specialist' craft production and elites, as has been frequently proposed for early metallurgy in the Balkans (see Chapter 3) becomes difficult to sustain (Brysbaert and Gorgues 2017).

Beyond the use of metal objects for daily activities, the communal nature of metal production in settlements and the relative lack of inequalities within those settlements provides support for the notion that investment in craft production may have been prompted by demands for ceremonial communal activities. Spielmann (2002) illustrates ethnographically that economic intensification, and even craft specialisation, can evolve to meet an increased demand for food, exchangeable items and paraphernalia required to take part in collective ceremonial events. In an extensive review of social complexity and inequality in the Chalcolithic Balkans, Porčić (2019a) notes that trends in the development of copper metallurgy and other crafts, the circulation and production of items of exotic raw materials, household size, cattle husbandry and population size all increase in the 5th millennium BC in comparison to the previous period. However, these markers remain at levels too low to ascribe to them the rise of inequality. He builds on this, arguing that the presence of craftspeople is not sufficient to claim the existence of an elite that supported them, nor that the economy at the time was directed from a single centre. Rather, the incentive for craft specialisation (in our case, metallurgy) came from a socio-political arena and as such might, for example, have developed to supply the need of all participants in ceremonial events that involved metal tools.

### *3. Desirable properties?*

The theoretical justification for elevated interpretative status of the metal objects in the Balkans is invariably justified by the distinctive forms produced, together with their material properties of hardness, lustre and colour. However, societies across the Balkans in the 5th millennium BC preferred brilliance, colour aesthetics, precision and geometric thinking. This preference dominates the material culture of the time (Chapman 2011) and has its roots in the Mesolithic period in the region (Chapman and Richter 2009; cf. Srejović 1972). Well-executed craftsmanship, bold colours, dramatic shapes and symmetrical design can be encountered combined in single objects in the 5th millennium BC Balkan material culture. For instance, a high degree of standardisation is seen in the production of flint blades from the Bükk culture (Vértes 1965), remarkable geometric precision in the pottery of the Cucuteni-Tripolye culture (Washburn and Crowe 2004), spectacular craftsmanship in the gold-decorated vessels in the Varna I cemetery (Ivanov 1988b), and outstanding painting techniques in the silver-sheen of graphite-painted pottery of the Karanovo-Gumelniţa-Kodžadermen (KGK) VI cultural complex, and beyond (Todorova and Vajsov 1993).

Hence, dazzling metals on the one hand and glittering black-burnished ware on the other represent only some of the spectacularly crafted objects in the wider context of the 5th millennium BC material culture in the Balkans (cf. Chapman 2011). What emerges as a pattern is not only the lustrous colour spectra, which continued to expand over the course of this period with the discovery of gold or tin-bronze, but also a specific pursuit for the ultimate expression of a completely homogenised brilliance only achieved with metals. In this light, the emergence and spread of metals—first copper, and in succession gold and tin bronzes—may be the best illustration of such a quest for the decisive material statement at the time. Radivojević and Rehren (2016) went as far to call this period the *Age of Brilliance*, to emphasise the importance of the production of highly reflective objects (e.g. metals, metal powder decorations on pottery, graphite painting) as an integral part of both cultural and technological identity.

Yet, the value of these properties may have varied during the 5th millennium BC. More generally, we see the majority of Vinča culture metal coming out of domestic contexts, while just after the mid-5th millennium BC the prevalent context for metals is burial grounds (Radivojević 2006). Examples from the domestic context emerge as heavily worked and even deformed (Šljivar *et al.* 2006), while implements from burial contexts at Varna or KGK VI burials are mostly 'as new', or with minimal traces of use wear. A future study in use-wear analysis of these implements would reveal a much needed high-resolution picture of consumer behaviour with regard to metal implements.

### *4. Kings of metal?*

The evidential basis for the debates connecting metal objects to societal elites in the Balkans tends to centre upon the cemetery site of Varna, Bulgaria which rapidly came to be considered the Type-site demonstrating the relationship between early metallurgy and a high level of social differentiation (e.g. Ivanov and Avramova 2000; Renfrew 1978a, 1986; Ivanov and Avramova 2000) and Chapter 3. Whilst not diminishing neither the site of Varna nor the related research, the quantity and quality of the metal evidence has completely overwhelmed ongoing and, indeed, increasingly circular, debates on early metals, elites and social complexity in the Balkans (e.g. Hansen 2012, 2013b; Kienlin 2010; Kienlin and Zimmermann 2012).

Whilst there is no doubt that there are substantial differences in the treatment of individuals across the Varna cemetery as discussed earlier (see Krauss *et al.* 2014, 2017), there have been few cemeteries excavated in the Balkans dating to *c.* 5000–3700 BC that are of comparable size (e.g., Durankulak, Bulgaria) (Todorova 2002a), and none that are comparable in metallurgical, or indeed material, extravagance in their grave goods, especially beyond northeastern Bulgaria (Lichter 2001). In the pursuit of markers for individual wealth, the most commonly cited example is the individual in burial No. 43. Yet, this burial is one of three skeletal graves in the assemblage of the 11 richest (or Group A), the other eight being symbolic graves or cenotaphs (Leusch et *al.* 2017: 112, Table 2). An interpretation of the symbolic graves suggests that wealth may have been deposited as an expression of 'collective social identity' and, as such, did not reinforce the social order but was made by communities to strengthen their ties with the dead (Biehl and Marciniak 2000: 202). This theory is supported by the fact that none of the deposited items had been used (some were even crudely made), and there is no evidence from the settlement research to show hierarchy or any form of strong social differentiation akin to that assumed in the cemetery (Ivanova 2007; Leusch *et al.* 2017: 113). By highlighting that the Varna cemetery was the end product of a dynamic process that mobilised all available resources to define and display the community's identity, Biehl and Marciniak (2000) approach the point that we are making above about the cooperative nature of metallurgical production in the Balkans.

Beyond Varna, the quantity and size of copper tools, primarily axes, known to have circulated in the Balkans is drawn upon when relationships between metals and elites are explored (Klimscha 2020). Ryndina (2009) estimates that the amount of metal circulating in the region translates into *c.* 4,300 artefacts whilst Chernykh (1992) proposes 4.7 tonnes. The amount of extant copper metal artefacts discovered across the Balkans in the 5th millennium BC outweighs the contemporary mining and production evidence. In addition to the beads, fish-hooks and awls already known from the late 6th millennium BC, this period witnessed an outburst in the production of massive copper implements—such as hammer-axes, chisels and bracelets—from the very beginning of copper smelting practices at *c.* 5000 BC. However, the figures, artefact discoveries and distributions reported need to be considered with caution as the number of extant copper implements in the Balkans predominantly date to the second half of the 5th millennium BC and may simply represent specific depositional or recycling practices (see Chapman and Gaydarska 2020; Taylor 1999). This is certainly highly significant when contrasting the Balkan evidence with that for metal artefacts known from the European and Near Eastern Bronze Ages (Radivojević *et al.* 2019) and potentially also earlier.

In the absence of any indication of centralised decision-making or elites, or even the presence of noticeable differences in wealth, it is safest to assume that the wealth we can identify belonged to a household unit, or groups of households representing an extended family, a clan or, indeed, a cooperative community. An interesting find from the Vinča culture site of Stubline potentially sheds a novel light on this perspective. Forty-three clay figurines were recovered together with eleven miniature clay models of (copper) implements in seven or eight spatial clusters (Crnobrnja 2011; Crnobrnja *et al.* 2009). These figurines were found arranged (Figure 3) in front of a large domed oven inside a dwelling structure, surrounded by ceramic materials typologically characteristic of the Vinča D2 phase, and dated to *c.* 4650/4600 BC (Crnobrnja 2011: 132). Forty-two figurines are identical in design: crudely shaped cylindrical bodies with a bird-like head, in contrast to a single large example that was made with more technical skill. All have a hole in the right shoulder; some of these holes presumably held the tool handles. However, not all the figurines have tools associated with them, implying that possibly these suffered from post-depositional processes. Unlike the figurines, the clay models of the implements were meticulously shaped and polished, with particular attention paid to fine details. Their form even allows for the distinguishing of different types of tools, such as hammer-axes, pickaxes, long tools with a blade, mallets and a macehead or 'sceptre' (Crnobrnja 2011: 134). Interestingly, some of the miniature implement models in clay are strikingly similar to their contemporaneous counterparts in copper metal, the Pločnik hammer axes for example, while counterparts for the macehead or 'sceptre' are found at Divostin II (House 13) or in the form of a gilded hammer axe at Varna 1 (burial No. 4) (Leusch *et al.* 2017: 113, Figure 7; Porčić 2019a).

Whilst the figurines at Stubline are undoubtedly important, exactly what they represent has been a matter of debate. The tall figurine with a macehead (status marker) may be interpreted as a representation of anything from a highly ranked individual to a deity, the presentation of a (equal) community with carefully and distinctively designed miners' and metallurgists' tools may represent one of our 'cooperatives' seen

Figure 3. A selection of the Vinča culture figurines from the site of Stubline. The central figure has a clay model of a sceptre; others have clay models of hammer-axes. (After Crnobrnja 2011: 140, Figure 9; copyright by A. Crnobrnja).

through the eyes of the artisan at the time. If the possession of copper was considered an indication of prestige or wealth, then the Stubline figurines may well show us that it was equally distributed within a practicing community. Finds like this tell us who the owners of these tools were not likely to be: 'kings' or any kind of gender-exclusive community.

### *5. Societal impact?*

With all the above evidence, we are increasingly witnessing a much more critical approach to long-held Childean ideas regarding early metallurgy, such as its close associations with emerging elites and major societal transformations (e.g. Bartelheim 2007; Biehl and Marciniak 2000; Chapman 1991; Kienlin 2010; Kienlin and Zimmermann 2012; Lichardus 1991c; Porčić 2012b, 2019a). The data presented here lead us to conclude that the invention of copper metallurgy at *c.* 5000 BC appears to have had very little impact on society at the time. However, the polymetallic (r)evolution with novel metals such as gold or bronze and a vast expansion of metal production and circulation from the mid-5th millennium BC played a significant role in individual and group identities. In the context of its early emergence at the sites of Belovode and Pločnik, we see a partial transformation of pottery production (diversification of forms, or recipes, see Chapter 43) and moderate changes over time in diet, subsistence and dwelling habits, which by being correlated with the presence of metals in the lives of the Belovode and Pločnik communities, do not offer enough information to argue for causation of these phenomena.

The considerably nuanced view presented in this chapter and throughout the monograph adds a particular value for future explorations of the societal impact of metallurgy. At a broader spatial and temporal scale, we can gain clearer insights into the relationships between metallurgy and metallurgists and the organisation of these communities across the Balkans – not by the vague identification of a metal-using 'elite' but by exploring how metal relates to broader demographic patterns, settlement densities and connections between communities. Belovode and Pločnik stand out for sharing the same supply networks and/or deposits in relation to copper mineral or copper ore acquisition from the very beginning (51st century BC) until the end (46th century BC) (Chapter 41). During this time, both the technology of copper making and the copper supply are consistent and unchanging. The dominant mode of production remains the hole-in-the-ground installations, implements are made from almost pure metal in a selected number of types and even finishing techniques (annealing + hot/cold working) remain the same. The continuity and consistency of copper smelting technology suggest that such knowledge in the Vinča culture was likely passed on as an 'all-in-one' package within a potentially conservative tradition. The transmission of knowledge was perhaps kept within a particular lineage of craftspeople, or a cooperative, where skills were most likely passed from a senior member or parent to the offspring or apprentice? (cf. Shennan and Steele 1999).

The size of a learning network has been shown to be very important for skills transmission in traditional and prehistoric communities (Henrich 2004; Powell *et al.* 2009; Roux 2008; Shennan 2001). As for any innovation, the spread of metallurgical skills within the Vinča culture required a sufficient number of learners. Given the consistency of selection practices of black-and-green ores and copper smelting technology throughout *c.* 600 years, this appears to have been stable during this period. The learning network of Vinča culture metalworkers ceased to exist at Belovode and Pločnik (and also Vinča and Gornja Tuzla) around the mid-5th millennium BC, with the end of the Vinča culture, so mysteriously marked by an abandonment of these and other settlements in modern day Serbia. Nonetheless, the continued production of massive copper implements across the Balkans throughout the entire 5th millennium BC, suggests that this learning network possibly continued to grow in other parts of the region.

Recent research has revealed a clear increase in the population of settlements during the Balkan Chalcolithic (Porčić 2019a) and, by extension, in population densities at settlement sites (Rosenstock *et al.* 2016). These two trends would have significantly enhanced any production activities that required communal and cooperative dynamics – as can be demonstrated for metal production. When integrated with the evidence from network analyses that communities were frequently and regularly cooperating in the production and distribution of metal artefacts (cf. Radivojević and Grujić 2018a), it is clear that the societies in the Balkans provided an institutional and technological context within which metallurgy was able to thrive. However, there is no evidence to suggest that metal played either a causal role, whether in creating a larger and more densely settled population in the region, or in the inter-connections spanning the many communities, as both trends can be seen to emerge in the 6th millennium BC (Porčić 2019a). The influence of metallurgy and metallurgists on the diversity of partially overlapping and fluctuating communities across the Balkan societies may instead have been in the development of existing areas or the creation of new areas of cooperation and connections within and between communities. It is only when (as here) metals are compared to other widely distributed materials and technologies that both pre-date and are contemporary with metallurgy—such as obsidian and graphite-painted pottery—that their role can be more thoroughly re-evaluated. Our evidence makes it increasingly problematic to argue that metal defined the organisation of these communities.

There is, however, a notable increase in wealth during the 5th millennium BC in the Balkans. Orton (2010) and Orton and colleagues (2016) indicate a general increase in the number of cattle bones in faunal assemblages, which may have been partially due to investment in the social arena, with cattle representing a form of wealth (cf. Russell 1998). Moreover, the difference in wealth can be seen in the presence of status markers such as the macehead (*sensu* Siklósi 2004; 2013) from Divostin II, found in House 13, which also differs in size and assemblage from other excavated houses at this site (Porčić 2009, 2012b). The same applies in relation to the presence of large houses and households in settlements like Divostin and Stubline, which Tripković (2009a) argues to reflect the existence of extended or multi-family households. The creation of larger basal units (such as households) and many levels of decision-making is at the core of Porčić's (2019a) argument that Vinča society was most likely organised as a sequential hierarchy (*sensu* Johnson 1982), or with decisions made by consensus within a household group, before a representative would negotiate on their behalf at a village level. This kind of organisation enabled a relatively egalitarian decision-making process. In this context, the interpretation of large buildings with house floor areas between 100 and 200 square metres is of great significance. As there is no evidence to suggest that such buildings were homes to local elite or were temples (Chapman 2010), they can perhaps be seen as communal buildings that enabled the working of sequential hierarchies, as their size fits the low level of integrative facilities (Porčić 2019a).

## The Eurasian context

We now see that, across Europe and Asia in the 5th and 4th millennium BC, the introduction of different metals and technologies varies across three geographically and geologically neighbouring 'heartlands' of metallurgy: the Balkans, Anatolia and Iran. For instance, in the Balkans, the polymetallic 'revolution' occurs around the mid-5th millennium BC when, after *c.* 500 years of making only copper (and possibly lead), we see gold, tin bronze and, most likely, silver being produced before the end of the millennium. In Iran, early metal use starts as in the Balkans (with copper and some lead). however, despite evidence for the silvery alloy CuAs from the early 5th millennium BC, true polymetallism occurs in Iran towards the end of the 5th millennium BC and beginning of the 4th millennium BC with a complex range copper alloys, gold and silver; tin-bronzes do not appear before the end of the 4th millennium BC. For Anatolia, native and/or smelted copper is the primary choice until the mid-4th millennium BC, when silver-like alloys first emerge (CuAs, CuAg), followed by tin-bronze at the same time as in Iran (data from Lehner and Yener 2014; Leusch *et al.* 2015; Radivojević and Roberts 2013; Radivojević *et al.* 2013; Roberts *et al.* 2009; Thornton 2001, 2007, 2009, 2010). The different intellectual traditions, languages of scholarship and contemporary politics in each region has meant that, despite geographical proximities and interconnected underlying geologies, early metallurgical research at a broader pan-regional spatial scale is significantly under-developed. Yet, the fundamental conclusion drawn from these comparisons is that there is no single narrative for metal technology that unites these neighbouring regions , or indeed the adjacent metallurgical 'heartland' of the Caucasus (Courcier 2014) into a single entity in the 5th or 4th millennium BC.

Just as no single narrative unites the evolution of metallurgy during this period, neither does a single narrative explain and interpret the societal impact of this technology. We acknowledge that many interpretative models that include the emergence of elites and social complexity as a direct consequence of making and trading metal artefacts drew on far less data of a lower resolution than is available in the 21st century. It is on the shoulders of intellectual giants like V.G. Childe, T. Wertime, C. Renfrew, S.C. Smith, B. Jovanović, E.N. Chernykh and many others that we stand and build a new, more nuanced view of what modern archaeological perspectives on *The Rise of Metallurgy in Eurasia* meant for farming communities in the Balkans during the 5th millennium BC.

First and foremost, the emergence of metallurgy was a technological revolution. Like no other before, it transformed matter from ore to metal and demanded a skilled manipulation of fire in order to yield workable results. It built on and interacted with the exceptional crafting of shiny and colourful artefacts from clay over the course of the 5th millennium BC. Its value differed, both from earlier to later centuries and from the places of production to the places of consumption. While the produced metal objects may have played a significant role in various ceremonies, the early onset of production itself was very likely a community effort that took place in shared spaces, probably with music and accompanying rituals. This ‘cooperative’ practice is further underlined by the absence of evidence in the excavation record for a specialist in the Vinča culture and beyond (with Varna as the exception rather than the rule).

The increasing wealth of the metal producing and consuming societies in the Vinča culture may have been influenced by metallurgy, although probably not to the extent of causing increases in population, livestock management, expanding households or possession of other commodities, and we see no clear evidence that any of these factors worked independently. This brings us to a novel narrative of the evolution of copper metallurgy in the Balkans, the only independent feature of which lies in the invention of this technology with a particular choice of crucial ingredients, such as black-and-green copper ores, and following a unique technological trajectory within the Vinča culture community to begin with. However, detailed excavations, high resolution materials and networks analysis of archaeometallurgical materials indicate the importance of communal practices and cooperation, which also emerge as the main points from analysis of other aspects of material culture, including examples from across the 5th millennium BC Balkans – most of them previously underappreciated for their explanatory powers.

Hence, we propose that the strength of shared practices and cooperation should be brought to the core of future archaeological inquiry on the topic of early metallurgy may pursue in the future, in the Balkans, across Eurasia, and globally. As highlighted in the subsequent chapter (Chapter 53), we take inspiration from major recent developments in the understanding of the processes involved in the global domestication of animals and plants, which is now thought to have taken place independently in sixteen geographical centres (Larson *et al.* 2014). We also recognise that, following Graeber and Wengrow (2021), with access to new and better data it is imperative that we use it to critically evaluate our own ideas and established interpretations, as well as remaining open to braving new explanations.

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The bibliographic reference for this chapter is:

Radivojević, M. and Roberts, B. W. 2021. Balkan metallurgy in a Eurasian context, in Radivojević, M., Roberts, B. W., Marić, M., Kuzmanović Cvetković, J., and Rehren, Th. (eds) *The Rise of Metallurgy in Eurasi*a: 601–618. Oxford: Archaeopress.

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*The Rise of Metallurgy in Eurasia* is a landmark study in the origins of metallurgy. The project aimed to trace the invention and innovation of metallurgy in the Balkans. It combined targeted excavations and surveys with extensive scientific analyses at two Neolithic-Chalcolithic copper production and consumption sites, Belovode and Pločnik, in Serbia. At Belovode, the project revealed chronologically and contextually secure evidence for copper smelting in the 49th century BC. This confirms the earlier interpretation of c. 7000-year-old metallurgy at the site, making it the earliest record of fully developed metallurgical activity in the world. However, far from being a rare and elite practice, metallurgy at both Belovode and Pločnik is demonstrated to have been a common and communal craft activity.

This monograph reviews the pre-existing scholarship on early metallurgy in the Balkans. It subsequently presents detailed results from the excavations, surveys and scientific analyses conducted at Belovode and Pločnik. These are followed by new and up-to-date regional syntheses by leading specialists on the Neolithic-Chalcolithic material culture, technologies, settlement and subsistence practices in the Central Balkans. Finally, the monograph places the project results in the context of major debates surrounding early metallurgy in Eurasia before proposing a new agenda for global early metallurgy studies.

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